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On  
DISC BIASING APPARATUS WITH A SPLIT-FINGER BIASING TOOL FOR A DATA  
STORAGE DEVICE

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**DISC BIASING APPARATUS WITH A SPLIT-FINGER BIASING TOOL  
FOR A DATA STORAGE DEVICE**

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**Field of the Invention**

This invention relates generally to the field of magnetic data storage devices, and more particularly, but not by way of limitation, to a disc biasing tool with a split-finger biasing tool for biasing a disc relative to a central axis of a  
5 motor hub of a data storage device.

**Background**

A key component of a computer system is a device, (such as a data storage device DSD) to store data. The most basic parts of a DSD includes an information  
10 storage disc (disc) that is rotated, an actuator that moves a read/write head (head) to various locations over data tracks of the disc, and electrical circuitry used for encoding data so that the data can be successfully retrieved and written to the disc surface. Servo tracks are provided on the disc surface to foster positional control of the head relative to the disc surface during data exchange operations. A  
15 microprocessor controls most of the operations of the DSD including exchanging data between the computer system and the DSD.

Among the challenges associated with data storage device assembly processes are; cost effective techniques for attaining a substantial coexistence between an axis of rotation of a motor hub rotating the disc, assuring a center of  
20 rotation for the servo tracks, and minimizing imbalanced rotation of the disc. Improved control over imbalanced rotation of the disc and substantial attainment of the coexistence between the rotational center of the servo tracks and the axis of rotation of a motor hub enhances attainment of increased storage capacity of the DSD.

25 As such, challenges remain and a need persists for cost effective techniques for rotational balance control and substantial coexistence between an axis of rotation of a motor hub and a center of rotation for the servo tracks of a DSD.

### Summary of the Invention

In accordance with preferred embodiments, a method, apparatus, and combination are provided for aligning an annular servo track with a center of rotation offset from a central axis of rotation of a motor hub by biasing a storage disc (disc) (upon which the annular servo track is written) adjacent the motor hub. Alignment of the center of rotation of the annular servo track with the central axis of rotation of the motor hub forms a common rotational axis for the motor hub and the annular servo track, as well as substantially offsetting a rotational imbalance of the discs for data storage devices having a plurality of discs.

In one embodiment, the biasing apparatus preferably has a biasing tool with a main body portion, at least a first and second biasing finger wherein each biasing finger has a proximal end and extends from the main body portion. The biasing tool further preferentially includes a disc engagement region protruding from a distal end of each biasing finger and an attachment aperture confined within the main body portion, for accommodating alignment of each disc alignment region relative to the disc.

In another embodiment of the present invention, the preferred steps of the method includes: providing the motor hub supporting a disc having an annular servo track with a center of rotation written on the disc offset from a central axis of rotation of the motor hub; aligning a biasing tool (preferably having at least a first and second biasing finger) adjacent the disc; and selecting a disc engagement region of one of the biasing fingers for engagement with the disc.

The preferred method steps continue with imparting a bias force on the disc with the selected engagement region, which aligns the center of rotation of the annular servo track with the central axis of rotation of the motor forming a common rotational axis, for the motor hub and the annular servo track.

A further embodiment of the present invention includes a data storage device preferably comprising, a disc biased adjacent a motor hub by the biasing apparatus executing the preferred steps of the method.

These and various other features and advantages that characterize the claimed invention will be apparent upon reading the following detailed description and upon review of the associated drawings.

### **Brief Description of the Drawings**

FIG. 1 is a partial cut-away top plan view of a data storage device (DSD) with a disc aligned to a motor hub of the DSD by a preferred embodiment of a  
5 biasing apparatus of the present invention.

FIG. 2 is a top plan view of a plurality of annular servo tracks written on the disc of FIG. 1.

FIG. 3 is a partial cut-away, cross-sectional elevational view of the preferred embodiment of the biasing apparatus of the present invention.

10 FIG. 4 is a partial cut-away, cross-sectional elevational view of a biasing tool of the biasing apparatus of FIG. 3.

FIG. 5 is a top plan view of a preferred embodiment of the biasing tool of FIG. 4.

15 FIG. 6 is a side elevational view of the preferred embodiment of the biasing tool of FIG. 5.

FIG. 7 is an end elevational view of the preferred embodiment of the biasing tool of FIG. 5.

FIG. 8 is a perspective view of the preferred embodiment of the biasing tool of FIG. 5.

20 FIG. 9 is a top plan view of an alternate preferred embodiment of the biasing tool of FIG. 4.

FIG. 10 is a side elevational view of the alternate preferred embodiment of the biasing tool of FIG. 9.

25 FIG. 11 is an end elevational view of the alternate preferred embodiment of the biasing tool of FIG. 9.

FIG. 12 is a perspective view of the alternate preferred embodiment of the biasing tool of FIG. 9.

FIG. 13 is a top plan view of another preferred embodiment of the biasing tool of FIG. 4.

30 FIG. 14 is a side elevational view of the preferred embodiment of the biasing tool of FIG. 13.

FIG. 15 is an end elevational view of the preferred embodiment of the biasing tool of FIG. 13.

FIG. 16 is a perspective view of the preferred embodiment of the biasing tool of FIG. 13.

FIG. 17 is a partial cut-away, cross-sectional elevational view of the biasing tools of the biasing apparatus of FIG. 3 prior to interaction with each disc of FIG.

5 1.

FIG. 18 is a partial cut-away, cross-sectional elevational view of the biasing tools of the biasing apparatus of FIG. 3 engaging discs of FIG. 1.

FIG. 19 is a partial cut-away, cross-sectional elevational view of the biasing tools of the biasing apparatus of FIG. 3 engaging all discs of FIG. 1.

10 FIG. 20 is a partial cut-away, cross-sectional elevational view of the biasing tools of the biasing apparatus of FIG. 3 aligning all discs of FIG. 1.

FIG. 21 is a partial cut-away, cross-sectional elevational view of the biasing tools of the biasing apparatus of FIG. 3, disengaging from all discs of FIG. 1, post alignment of all discs of FIG. 1.

15 FIG. 22 is a flowchart of preferred method steps for aligning the disc of FIG. 1 to the motor hub of FIG. 1.

### **Detailed Description**

Referring now to the drawings, FIG. 1 provides a top plan view of a data storage device (DSD) 100. The DSD 100 includes a base deck 102 cooperating with a top cover 104 (shown in partial cut-away) to form a sealed housing for a mechanical portion of the DSD 100, referred to as a head-disc assembly (HDA) 106.

25 A spindle motor assembly (motor) 108 rotates a number of data storage discs (disc) 110 with a magnetic recording surface (surfaces) 111 at a substantially constant operational speed. An actuator assembly (actuator) 112 supports and rotates a number of read/write heads (heads) 114 into a data exchange relationship adjacent the surfaces 111, when current is applied to a coil 116 of a voice coil motor (VCM) 118. A head suspension 120 provides a predetermined spring force on the head 114 to maintain the proper data exchange relationship between the head 114 and the disc 110 during operation of the DSD 100. Additionally, the head suspension 120 serves to connect the head 114 with an actuator arm 122 of the actuator 112.

During operation of the DSD 100, the actuator 112 moves the heads 114 into the data exchange relationship with the disc 110, i.e., the actuator 112 moves the heads to data tracks 124 on the surfaces 111 to write data to and read data from the disc 110. When the DSD 100 is deactivated, the actuator 112 positions the  
5 heads 114 adjacent a home position 126, and the actuator 112 is confined by latching a toggle latch 128.

Command, control, and interface electronics for the DSD 100 are provided on a printed circuit board assembly 130 mounted to the HDA 106. During data transfer operations, a preamplifier/driver (preamp) 132 attached to a flex circuit  
10 134 conditions read/write signals conducted by the flex circuit 134 between the printed circuit board assembly 130 and the heads 114.

In a preferred embodiment, the disc 110 is clamped adjacent a motor hub 136 of the motor 108 by a disc clamp 138. The disc clamp 138 assures that the disc 110 remains in a fixed position, relative to the motor hub 136, while the motor  
15 108 rotates the motor hub 136 during operation of the DSD 100. Additionally, the disc 110 in a preferred embodiment is biased adjacent the motor hub 136, in a predetermined direction, just prior to completing installation of the disc clamp 138 onto the motor hub 136. In a preferred embodiment, biasing the disc 110 adjacent the motor hub 136, aligns a plurality of annular servo tracks (not shown) written on  
20 the disc 110.

FIG. 2 shows a preferred embodiment of the plurality of annular servo tracks 140; having a center of rotation 142 offset from a rotational center 144 of the disc 110. The center of rotation 142 of the plurality of annular servo tracks 140 is confined within a mounting aperture 146 of the disc 110, and aligning between  
25 the rotational center 144 of the disc 110 in an index feature 148. The index feature 148 is adjacent an outer diameter 150 of the disc 110, and the mounting aperture 146 is confined within an inner diameter 152 of the disc 110.

FIG. 3 shows a preferred embodiment of a biasing apparatus 154 of the present invention having a biasing tool support structure 156. The biasing  
30 apparatus 154 provides a plurality of motion generating means 158. In a preferred embodiment, the plurality of motion generating means 158 are flow controlled pneumatic cylinders. However, one skilled in the art will readily recognize; the motion provided by the plurality of motion generating means 158 may be

accomplished by a number of alternate devices such as linear motors, worm gears, rack and pinion arrangements, stepper motors, or any alternate motion generating device.

5 Preferably, each of the plurality of motion generating means 158 is attached to a pusher block 160, in which the pusher block 160 supports a biasing tool 162 (also referred to herein as a “split-finger” biasing tool 162). Each biasing tool 162 provides at least two biasing fingers such as 164 and 166 with a disc engagement region 168.

10 In a preferred embodiment, the biasing tool support structure 156 is raised or lowered, relative to the motor hub 136 supporting the plurality of discs 110, to position each disc engagement region 168 of the biasing tool 162 relative to a corresponding disc of the plurality of discs 110, and one of the plurality of motion generating means 158 operates to engage or disengage the disc engagement region 168, with which a disc of the plurality of discs 110 corresponds.

15 Preferentially, each biasing finger, such as 164 or 166, independently interact with its corresponding disc of the plurality of discs 110, to assure each disc of the plurality of discs 110 responds only to the disc engagement region 168 of one of the biasing fingers, such as 164 or 166. Each biasing finger of the plurality of biasing fingers, such as 164 or 166, corresponding to each one of the plurality of discs 110, isolates interaction between the discs 110, which are simultaneously  
20 responding to an interaction with their corresponding biasing finger.

In other words, when biasing each disc of the plurality of discs 110, each disc 110 is individually biased, and a simultaneous biasing of the other discs of the plurality of discs 110 does not influence the individual behavior of any of the discs  
25 110.

If a biasing tool provides only one biasing finger, such as 164 or 166, but includes at least two disc engagement regions 168, attainment of properly biased discs 110 may be difficult, due to variability between the discs 110. Variability of either the outer diameter 150 or the inner diameter 152 (both of FIG. 2), or both,  
30 may lead to non-attainment of properly biased discs 110. For example, a mismatch in outer diameters 150 of a number of discs of the plurality of discs 110 may lead to discs among the plurality of discs 110 with smaller diameters failing to be displaced by a sufficient amount to attain a complete biasing. Therefore, failing to

align the center of rotation 142 (of FIG. 2) of the plurality of annular servo tracks 140 (of FIG. 2) with a central axis of rotation 170 of the motor hub 136 to form a common rotational axis, performance requirements of the DSD 100 (of FIG. 1) may be unattained, or a substantial offsetting of rotational imbalance of the discs 110 of the DSD 100 may not be achieved.

By biasing each of the plurality of discs 110 in a predetermined direction, rotational imbalance of the discs of the DSD 100 is significantly reduced, and in a number of instances, the rotational imbalance is eliminated. For example, for a DSD 100 with a pair of discs 110, each of the pair of discs 110 is biased along a common line, but biased in opposing directions toward the central axis of rotation 170 of the motor hub 136. For a DSD 100 with three discs 110, the predetermined direction for biasing each disc 110 is toward the central axis of rotation 170 of the motor hub 136, but rather than the bias force being applied to each disc 110 along a common line, the bias force is applied along lines separated by 120 degrees.

FIG. 4 shows a bias finger flex aperture 172 provided by the biasing tool 162, which defines the biasing tool 162 as a split-finger biasing tool 162. The biasing finger flex aperture 172 accommodates slight dimensional variations between each of the plurality of discs 110 during a biasing procedure. It will be noted that the dimensions of the biasing finger 164 is different than the biasing finger 166. The dimensions of the biasing finger 164 and the biasing finger 166 are selected to meet attainment of a common predetermined bias force, as illustrated by a force vector 174. The bias force is specific to both the configuration of a DSD and the process selected for producing that particular DSD. The dimensional characteristics of the biasing finger flex aperture 172 is determined by an amount of flex each biasing finger of the biasing tool 162 undergoes, to assure that only the predetermined bias force illustrated by the force vector 174 is imparted on each disc 110 during the biasing procedure, and to preclude interaction between the biasing fingers 164 and 166.

FIGS. 5, 6, 7, and 8 are preferably viewed together. Collectively, FIGS. 5, 6, 7, and 8 illustrate one of the plurality of biasing tools 162 of the biasing apparatus 154 (of FIG. 3). The biasing tool (collectively illustrated by FIGS. 5, 6, 7, and 8) is configured to accommodate a top disc and a bottom disc of a four disc stack of a HDA (such as HDA 106 of FIG. 1).



FIG. 5 shows an attachment aperture 176 confined by a main body portion 178 of the biasing tool 162. The attachment aperture 176 accommodates alignment of each disc alignment region of the biasing tool 162 with the disc 110 (of FIG. 1) of the HDA 106, with which the disc 110 corresponds.

5           FIGS. 9, 10, 11, and 12 are preferably viewed together. Collectively, FIGS. 9, 10, 11, and 12 illustrate another of the plurality of biasing tools 162 of the biasing apparatus 154 (of FIG. 3). The biasing tool 162 (collectively illustrated by FIGS. 9, 10, 11, and 12) is configured to accommodate any two adjacent discs of a disc stack of a HDA (such as HDA 106 of FIG. 1).

10           FIGS. 13, 14, 15, and 16 are preferably viewed together. Collectively, FIGS. 13, 14, 15, and 16 illustrate yet another of the plurality of biasing tools 162 of the biasing apparatus 154 (of FIG. 3). The biasing tool 162 (collectively illustrated by FIGS. 13, 14, 15, and 16) is configured to accommodate an outer two of any three adjacent discs of a disc stack of a HDA (such as HDA 106 of FIG. 1).

15           It will be noted, that any configuration of the biasing tool 162 may be adjusted to accommodate a disc of a HDA (such as HDA 106 of FIG. 1) consisting of a single disc. For data storage devices (such as DSD 100 of FIG. 1) that utilize a single disc 110 that incorporates the plurality of annular servo tracks 140 having their center of rotation 142 offset from the rotational center 144 of the disc 110 (as shown by FIG. 3), biasing the single disc 110 is a preferential process for the HDA 106 to undergo.

20           FIGS. 17, 18, 19, 20, and 21 are advantageously viewed together. Each of the FIGS. 17, 18, 19, 20, and 21 are illustrative of a step in the biasing process. FIG. 17 shows the alignment of each of the disc engagement regions 168 with a disc of the plurality of discs 110 with which they correspond.

25           FIG. 18 shows a first engagement of a number of the discs 110 of the plurality of discs 110, by a number of the disc engagement regions 168, during the biasing process.

30           FIG. 19 shows engagement of the remaining discs 110 of the plurality of discs 110, with the remaining disc engagement regions 168, during the biasing process.

FIG. 20 shows the position of each disc of the plurality of discs 110 resulting from the final position of each disc engagement region 168, during the biasing process.

FIG. 21 shows disengagement of each of the disc engagement regions 168 from engagement with each of the plurality of discs 110, and the biasing tools 162 awaiting extraction by the biasing apparatus 154 from alignment with the plurality of discs 110.

FIG. 22 shows a preferred biasing method 200 for biasing a disc (such as 110) adjacent a motor hub (such as 136) beginning at start step 202 and continuing at process step 204. At process step 204, the motor hub with a central axis of rotation (such as 170) supporting the disc is provided. The disc preferentially includes an annular servo track (such as 140) with a center of rotation (such as 142) offset from the central axis of rotation of the motor hub.

At process step 206, a biasing tool (such as 162) preferentially provides at least a first biasing finger (such as 164) and a second biasing finger (such as 166), which is aligned adjacent the disc. At process step 208, a disc engagement region (such as 168) of one of the plurality of biasing fingers is selected for engagement with the disc.

The preferred biasing method 200, preferentially continues at process step 210 with a bias force (such as illustrated by force vector 174) imparted on the disc with the selected engagement region. The bias force aligns the center of rotation of the annular servo track with the central axis of rotation of the motor, thereby forming a common rotational axis for the motor hub and the annular servo track. The preferred biasing method 200 concludes at end process step 212.

Accordingly, in preferred embodiments, the present invention is directed to a biasing apparatus (such as 154), a method (such as 200) of biasing a disc (such as 110) adjacent a motor hub (such as 136), and a data storage device (such as 100) that includes the disc biased adjacent the motor hub by means for biasing a disc adjacent a motor hub, using steps for biasing a disc adjacent a motor hub.

In accordance with preferred embodiments, a method, apparatus, and combination are provided for aligning an annular servo track (such as 140) with a center of rotation (such as 142) offset from a central axis of rotation (such as 170) of a motor hub by biasing the disc (upon which the annular servo track is written)

adjacent the motor hub. Alignment of the center of rotation of the annular servo track with the central axis of rotation of the motor hub forms a common rotational axis for the motor hub and the annular servo track, along with substantially offsetting a rotational imbalance of the discs for data storage devices having a plurality of discs.

The biasing apparatus preferably has a biasing tool (such as 162) with a main body portion (such as 178), at least a first and second biasing finger (such as 164,166), wherein each biasing finger has a proximal end and extends from the main body portion. The biasing tool further preferentially includes a disc engagement region (such as 168) protruding from a distal end of each biasing finger, and an attachment aperture (such as 176) confined within the main body portion accommodates alignment of each disc alignment region relative to the disc.

The preferred steps of the method included: providing the motor hub, supporting a disc having an annular servo track with a center of rotation written on the disc, offset from a central axis of rotation of the motor hub (such as shown by process step 204); aligning a biasing tool preferably having at least a first and second biasing finger adjacent the disc (such as shown by process step 206); and selecting a disc engagement region of one of the plurality of biasing fingers for engagement with the disc (such as shown by process step 208).

The preferred method steps continue with imparting a bias force (such as illustrated by force vector 174) on the disc with the selected engagement region, which aligns the center of rotation of the annular servo track with the central axis of rotation of the motor forming a common rotational axis, for the motor hub and the annular servo track.

The present invention further includes the data storage device preferably comprising the disc biased adjacent the motor hub by the biasing apparatus executing the preferred steps of the method.

It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention haven't been set forth in the foregoing description, together with details of the structure and functions of various embodiments of the invention, this disclosure is illustrative only, and changes may be made in detail, especially in matters of structure and arrangement of parts within the principles of the present invention to the full extent indicated by

the broad general meaning of the terms in which the appended claims are expressed. For example, the particular elements may vary depending on the particular application of the biasing apparatus with a split-finger biasing tool, while maintaining substantially the same functionality without departing from the scope and spirit of the present invention. In addition, although the preferred embodiment described herein is directed to a biasing apparatus with a split-finger biasing tool for a data storage device, it will be appreciated by those skilled in the art that the teachings of the present invention can be applied to other systems without departing from the scope and spirit of the present invention.